

# **Considerations When Performing Icing Wind Tunnel Testing to Determine Critical Temperature**

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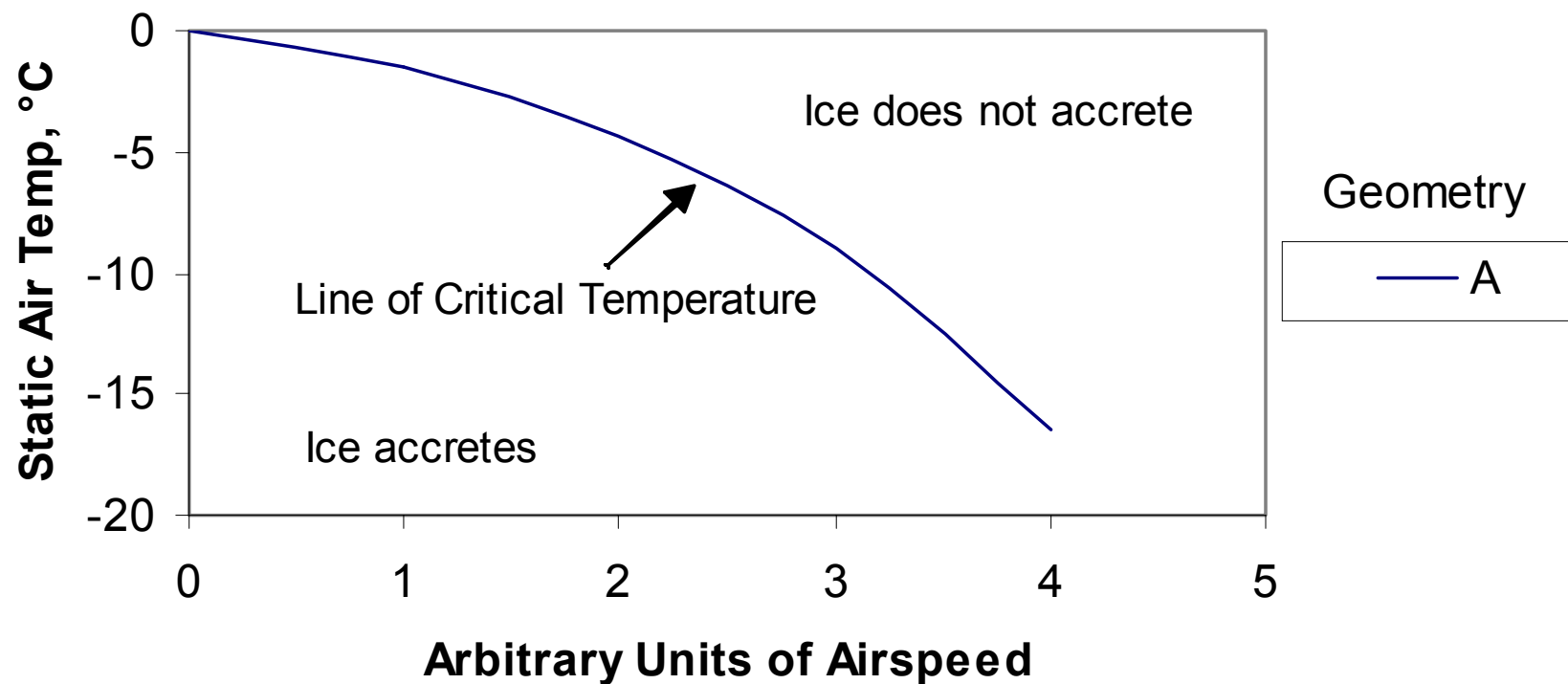
# Definition of Critical Temperature

- **Critical temperature** is the temperature above which ice will no longer accrete on a surface
- Critical temperature is usually expressed in terms of static air temperature, but total temperature can also be used

# Significant Factors that Influence Critical Temperature

- Airspeed
- Accreting body surface geometry
- Liquid water content
- Accreting body thermal properties

## Critical Temperature Illustration



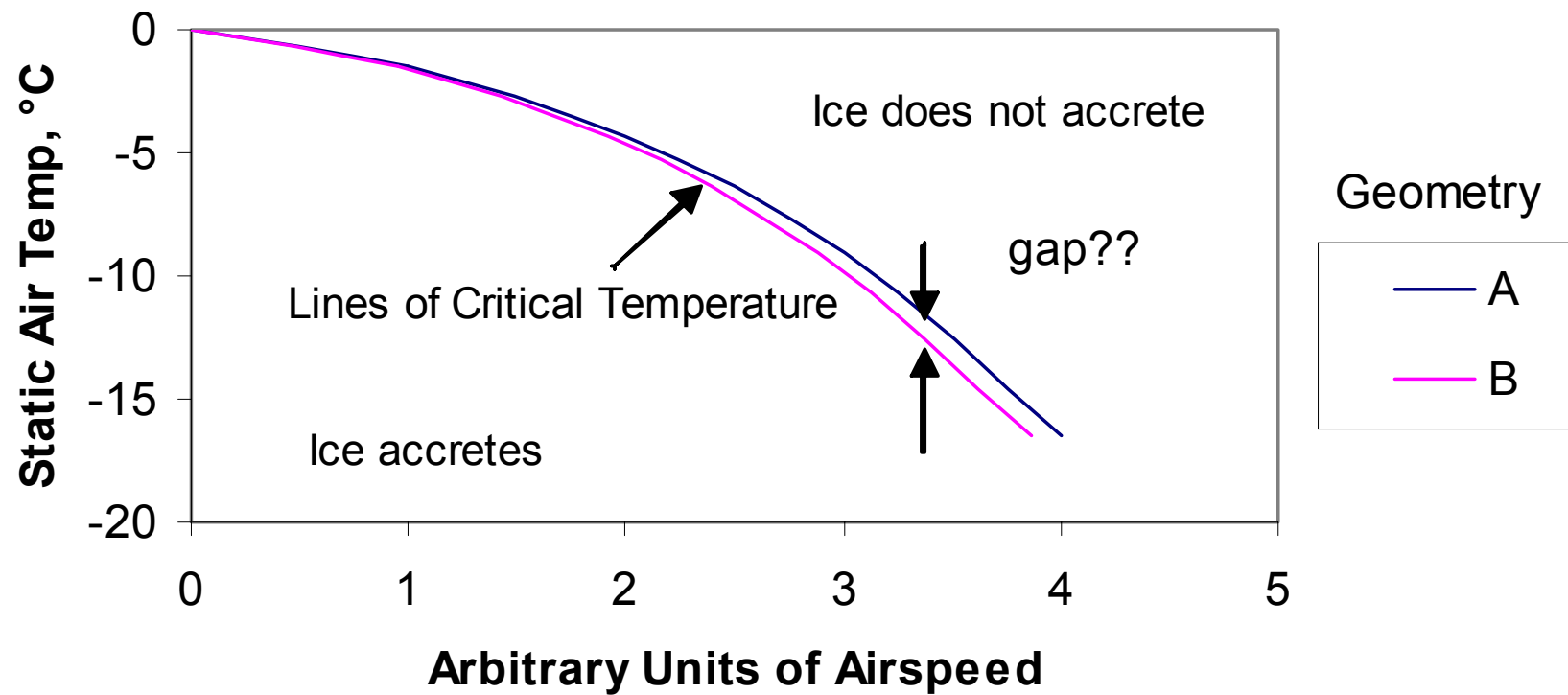
# Why Critical Temperature is of Interest

Might critical temperatures experienced by accretion-based ice detectors be appreciably **different** from those experienced at aircraft surfaces?



Accretion-based ice detector

## Critical Temperature Illustration



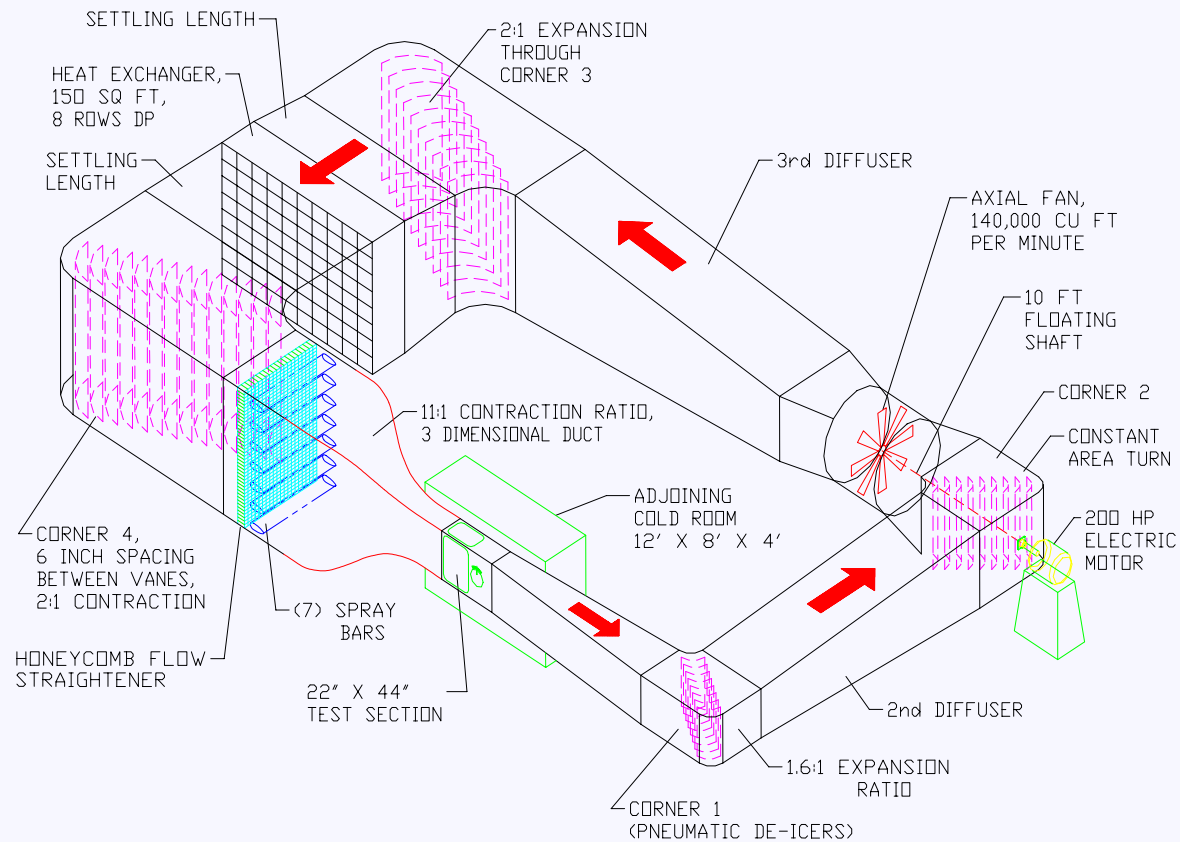
# Quantifying the Gap

- Limited testing and anecdotal information suggest that any gap is **small**.... on the same order, or less, as the measurement uncertainty for tools available to determine critical temperature
  - Tools include icing wind tunnels and analytical codes

# Quantifying the Gap

- Therefore, capability of current tools to accurately characterize critical temperature falls short of ideal
- Icing wind tunnels are perhaps the best tool available today

# Icing Wind Tunnel Schematic



# Icing Wind Tunnel Error Sources

- Primary contributors to uncertainty when determining critical temperature:
  - Temperature non-uniformity
  - Temperature standard accuracy
  - Ability to determine the onset of icing
  - Tunnel & test article thermal history
- Contributors are facility and test dependent

# Icing Wind Tunnel Error Sources

- Estimated contributions to uncertainty:

	<u>Error, <math>\pm</math> °C</u>
Temperature non-uniformity	1.0
Temperature standard accuracy	0.5
Determination of icing onset	0.3
Tunnel & test article thermal history	0.2
Other minor contributors	<u>0.3</u>
	<b>RSS: 1.2°C</b>

# Minimizing Errors

- Locate test articles where temperature is most uniform
- Be consistent in test method
- Scrutinize the calibration of temperature and temperature standards
- Observe surface temperature instrumentation response closely for evidence of icing onset
- Proceed slowly; seal leaks into test article cavities and passages

# Assessing Tunnel Test Results

- Establish uncertainty levels for the test, and consider measured critical temperature values in the **context of measurement uncertainty**.
- Consider tunnel test findings in the context of:
  - local aircraft icing conditions as influenced by aircraft geometry
  - real world transients due to changes in atmospheric conditions, aircraft attitude, & altitude

# Summary

- Critical temperature is the temperature above which ice will no longer accrete on a surface
- Differences in critical temperature between surfaces are generally believed to be small.... on the order of the uncertainty of the measurement tools currently available
- Uncertainty in critical temperature measurements determined using icing wind tunnels is on the order of  $\pm 1^{\circ}\text{C}$  to  $1.5^{\circ}\text{C}$
- Consider test results in the context of measurement uncertainty